The USAF Manufacturing Technology

# Program Status Report

Air Force Research Laboratory / Materials & Manufacturing Directorate / Manufacturing Technology Division / Wright-Patterson AFB, Ohio
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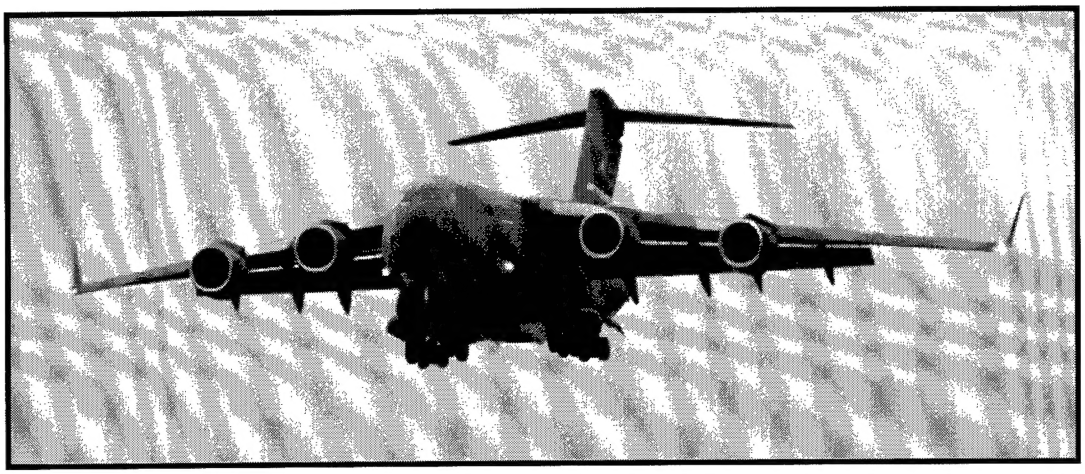
Summer 1999



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# Laser Projection System Improves Composite Structure Fabrication Process

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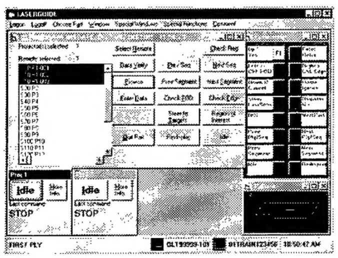


***Composites Manufacturing Process Control System display***

Scientists and engineers at Assembly Guidance Systems, Inc., and Bell Helicopter Textron, Inc., under contract with the Air Force Research Laboratory's Materials and Manufacturing Directorate (ML), have successfully developed a system that dramatically improves the process for fabricating aircraft composite structures.

The Composite Manufacturing Process Control System (CMPCS), developed under the Small Business Innovation Research (SBIR) program, reduces lay-up time, eliminates the need for lay-up templates, improves product quality, substantially lowers production costs and helps eliminate human error.

Almost all hand-laid composite parts are produced using templates to show the assembler where to place each component in the laminate. The templates are hard tooling, and are the full size and shape of the part to be produced. Studies show the time required to handle the templates is equal to the time required to place the actual composite materials into position. Another disadvantage is that using templates to inspect for proper ply location and orientation is expensive and cumbersome. In fact, template handling and deciphering time often exceeds the time required for the actual inspection. Human error during the lay-up of composite parts, such as incorrect location and orientation of the plies, foreign object damage, missing plies and incorrectly trimming material can account for up to 36 percent of the non-conforming parts.

Under this contract, research scientists and engineers successfully designed and developed a highly cost-effective process control system that addresses these key issues. The CMPCS significantly reduces lay-up time, eliminates lay-up templates, improves product quality, lowers production costs and reduces human error. CMPCS proof-of-concept was demonstrated during Phase I of a SBIR program begun in 1996, and successful development of the new system resulted in Phase II.

CMPCS incorporates an overhead projection system which uses optical imaging to provide accurate laser patterns showing placement locations for the composite material and core. The system provides real time, automatic in-process verification and documentation of each ply of composite material while it is being laid up. The non-value-adding costs of template fabrication, storage, retrieval, registration, deciphering, scribing, reworking and training are eliminated with CMPCS. The system is portable and can be set up by one person in less than 15 minutes. It can function as a complete, stand-alone system but can be integrated with other systems such as filament winders, automatic compaction systems or tape layers.

Built-in quality realized through CMPCS helps reduce composite structure inspection, rework and scrap costs, dramatically improves product quality and results in lower overall acquisition costs. CMPCS technology has been successfully applied in the Air Force C-17 program and has been validated for use in the Joint Strike Fighter and F-22 programs and the Navy's V-22. Combined savings projections already exceed $600,000 annually. The system has also been studied by the National Air and Space Administration for use in the X-33 reusable launch vehicle program, and by the Boeing Company and Sikorsky Helicopter. Twenty-four units have been sold to the aerospace industry. Other prospective applications include wiring harnesses, tube bending inspection and general aircraft assembly. Continued application of the new system could save the Air Force and private industry millions of dollars and lead to improvements in manufacturing processes over a wide spectrum of products and services.

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For more information, circle Reader Response Number 1

# Advanced Modular Factory Speeds Up Delivery, Demonstrates Lean Methods

Raytheon Missile Systems (RMS), under contract to the Air Force Research Laboratory's Materials and Manufacturing Directorate (ML), has successfully demonstrated cost-effective ways for improving tactical missile delivery programs using lean aerospace production methods.

Researchers demonstrated an advanced modular factory (AMF) approach for manufacturing defense products by targeting specific production facilities, identifying high-payoff changes and effectively demonstrating world-class quality manufacturing. These actions resulted in reducing inventory, cycle time, material handling and warranty costs and generated a 40 percent reduction in the order fulfillment time for the Advanced Medium Range Air-to-Air Missile (AMRAAM).

In the near future, military customers will require rapid deployment of new technology to respond to new and unanticipated battlefield threats. U.S. defense contractors have responded well in the past, however, changes in the defense business climate and the battlefield require capabilities that provide warfighting products more rapidly.

As improvements are made to develop products faster and cheaper, defense contractors must be responsive to alternative product configurations, while producing lower quantities. Lean production appears to be a prerequisite for defense business in the 21st century as military customers require continually shorter cycle times for low production volumes of highly specialized products at lower costs. As a result, defense contractors have been slowly migrating toward lean principles. It was not, however, until the Lean Aerospace Initiative (LAI) got underway that companies started realizing the applicability and benefits of pursuing lean operations.

Engineers at RMS, working with ML, conducted a highly detailed analysis of the order fulfillment (customer order to product delivery) process used to deliver tactical missiles. RMS used its current factory operations and AMRAAM Lot 12 production as the target of the study. Five major tasks were completed during the analysis which yielded metrics that can be used to reduce the cycle time and cost of products and services when linked to a company's operating strategy. The primary objective was to demonstrate an advanced modular factory (AMF) approach for manufacturing defense products, such as the AMRAAM. The researchers achieved this by: establishing models and simulations that allow a concise understanding and evaluation of the flow process; reducing set-up times; implementing process owner inspections throughout the value chain; striving for single-piece flow; minimizing the space used and distance traveled by personnel and material; synchronizing production and delivery in the value chain; and maintaining equipment which minimized unplanned stoppages.

The research team also demonstrated how to reduce order fulfillment lead time on the AMRAAM by more than 40 percent, while eliminating critical path waste, and lead time, internal/external cycle times and inventory levels and simultaneously increasing inventory turns, quality and financial performance. RMS also developed a technology transfer methodology to help other organizations assimilate AMF and lean improvement processes and metrics.

The AMF achieves significant improvements by: evaluating cost-time activities from the receipt of customer order to product delivery; identifying the value-added and non-value-added activities in the process, making the improvements and performing demonstrations of improved operations; measuring the results via tactical and strategic pathfinder improvements, workshops and studies; iterating the processes to capture and enhance the results and learning; and reporting and performing technology transfer. Continuing efforts in this area could lead to substantial savings for the Air Force and more rapid delivery times for other missile programs.

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For more information, circle Reader Response Number 2

# Microwave Probe Revolutionizes Material Coatings Examinations

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An innovative research effort supported by Air Force Research Laboratory's Materials and Manufacturing Directorate (ML) has led to the development of a sensor device that could revolutionize how coating properties are examined on space vehicles, computer components and other military and commercial products.

Developed for the Air Force under the Small Business Innovation Research (SBIR) program, the probe uses microwaves to determine the spatial distributions of electrical resistivity and other electromagnetic properties of conducting, semi-conducting and insulating materials without damaging the material structure.

Increased emphasis on space exploration has prompted Air Force materials engineers to be more focused on examining property changes in thin-film coatings on space vehicle components. However, until recently, these changes could be studied only after the coatings were applied and had transformed, limiting the understanding of the process as well as preventive measures to strengthen and preserve the integrity of the coatings.

Scientists at ML entered into a SBIR research and development effort with the Manufacturing Instrumentation Consulting Company, in Cleveland, Ohio, to improve the examination process using evanescent microwave technology developed by Dr. Massood Tabib-Azar, a professor at Case Western Reserve University (CWRU). Based on initial research findings published in 1993, the program sought to provide Air Force material researchers with an opportunity to examine composition changes while they occur, in real time.

The evanescent microwave probe has only been used in government tests, yet has demonstrated a strong potential for applications ranging from checking the reliability of computer components and handheld wireless circuitry to imaging tooth decay. The probe is about one-fourth the thickness of a strand of human hair and is capable of generating high-resolution images as it draws nearer to a sample using suitable microwave frequencies. Two evanescent microwave probes are currently being tested by Dr. Tabib-Azar's research team. The larger of the two probes is used to scan highly detailed material samples such as surface areas of computer circuit boards. The smaller one provides large area scans for low-resistivity samples. Both sensors are maintained and operated at a research laboratory near CWRU.

Scanning of highly detailed coating surfaces requires the use of a computer to track values and produce the scans. The system maps the variation in amplitude of the reflected electronic wave as the microwave probe is moved across the sample at a known distance. The resultant scans are then analyzed to determine the properties of the sample material, while providing important information to the research team on the coating's integrity and durability, before the coating is applied to working components.

An ongoing example of this technology has been seen at the Electron Device Technology Branch of the National Aeronautics and Space Administration (NASA), which has been using the probe to characterize wireless circuits to be used in the space program. Because the probe is noninvasive, NASA technicians have been able to use it to check the reliability of the thin layers making up the multi-layered circuits, without removing them from the line. Two inherent advantages of the probe are its ability to scan surfaces without causing damage to the material and its ability to penetrate a sample material better than scanning acoustic microscopes. This ability could prove to be extremely useful and cost effective in analyzing aircraft coatings. The evanescent microwave probe also has many commercial applications and could revolutionize industries where imaging plays a major role.

For more information, circle Reader Response Number 3

# Composite Horizontal Stabilizer Developed For C-17 Aircraft

A research and development effort supported by Air Force Research Laboratory's Materials and Manufacturing Directorate (ML) has led to the use of a lighter-weight horizontal stabilizer outer torque box in the C-17 aircraft.

Designed under the Military Products Using Best Commercial/Military Practices pilot program, the improved tail component, which accounts for 80 percent of the horizontal structure, demonstrates and validates a host of far-reaching innovations directly impacting aerospace business practices, manufacturing infrastructure and process technology.

The objective of this program was to develop military products using the best commercial and military practices, and extend these practices throughout the factory to every part designed and manufactured in the enterprise, making significant gains in product affordability by developing new ways of doing business. To accomplish this, a team of product development experts comprised of both contractor and government personnel was formed to achieve the stated program target goals of a 50 percent reduction in acquisition costs and a 20 percent weight savings in the product: a C-17 horizontal stabilizer outer torque box.

The principle contributors in this effort included the Boeing Company, Northrop-Grumman, the Defense Contract Management Command, the C-17 System Program Office, and ML. The program's integrated product team used a structured approach for comparing commercial and military practices and processes and documenting cost/benefit analyses and risk assessments. They reinvented the traditional ways government and industry work together, resulting in the successful transfer of new business practices, manufacturing infrastructure and process technology to commercial industry.

Contrary to popular belief, the team found that commercial practices were not always the best and that military practices did not always add significant cost. The team successfully identified, evaluated, refined and documented best commercial/military practices and processes that streamline how a significant acquisition program is run. Using a fully integrated team approach, with all stakeholders as active participants and a relationship based on extensive communication and trust, the team significantly reduced government oversight and non-value added reporting requirements. They also identified more than 40 separate process and programmatic improvements that would result in significant savings at both the program and organizational level.

A comparison, based on the production of more than 2,700 commercial horizontal stabilizers and the first 20 production C-17 stabilizers, identified significant differences in both processes and practices as potential areas for affordability improvements. Discounting the effects of learning (rate production), the C-17 stabilizer was still over 2.06 times more costly than similar commercial class stabilizers. This analysis identified three targets of opportunity: product-related initiatives derived from product design which drive cost, weight, and product descriptions; process-related initiatives independent of product design that had major impacts on cost, span-time or flow down requirements; and programmatic initiatives impacting the total acquisition cost.

The new outer torque box incorporates three significant improvements: upper and lower carbon/epoxy skins with integral hat stiffeners; carbon/epoxy front and rear spars with co-bonded stiffeners; and integrally machined clips and brackets as part of the rib design. These improvements reduce overall touch labor, support labor and material requirements. Electronic design tools, modeling and virtual reality were also incorporated into the design process, saving more than two million dollars by eliminating engineering mock-ups.

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For more information, circle Reader Response Number 4

# Manufacturing Improvement Process Enhances Production Quality

Researchers from the Higher Education Manufacturing Process Applications Consortium (HEMPAC), in cooperation with the Air Force Research Laboratory Materials and Manufacturing Directorate (ML), have developed a technique for improving productivity and waste reduction at industrial plants.

The new technique, called the Manufacturing Improvement Process (MIP), integrates a common sense approach that enhances production quality while ensuring small manufacturers are able to respond quickly in the event of a national emergency. The technique has been implemented in Minnesota at 36 companies that help support the nation's defense needs.

Historic reductions in national defense expenditures in recent years have seriously impacted the industrial workforce. Such is the case in Minnesota, where about 1,200 of the state's 8,700 manufacturing firms are either prime or sub-contractors for the Department of Defense. The Minnesota Department of Trade and Economic Development estimates that approximately 45,000 defense-related positions were lost in Minnesota between 1987 and 1995. These job losses were primarily in machinery and computer equipment manufacturing.

During one three-year period alone, from 1989 to 1991, employment in this sector declined 10 percent. Hardest hit were manufacturers with less than 1,000 employees. This is because larger companies, in general, have the resources required to deal with cutbacks, whereas smaller companies tend to be more reliant on a fewer number of key contracts.

Despite draw downs in the defense industrial base, it's still vital for U.S. national security that small manufacturers remain capable of responding quickly to national emergencies. One of the best ways of accomplishing this is through continual improvements in manufacturing processes. Researchers at the HEMPAC, working with ML, developed a new productivity improvement waste reduction technique to strengthen Minnesota's defense-related industrial base. MIP is based on a concept referred to as Optimized Operations, developed by 3M Company and successfully implemented to support more than 200 projects at its own plants. MIP offers a model for problem solving that is applicable in a wide range of manufacturing situations, routinely identifies potential problems and avoids them before they arise. MIP also demonstrates long-term, ongoing benefits as well as short-term gains and integrates a common sense approach using a number of principles such as Just-in-Time and Total Quality Management, proven highly effective in improving both productivity and quality.

HEMPAC introduces MIP into an industrial plant by means of a six-month project specially designed to improve some aspect of plant operations and by training plant employees on subjects related to the success of the project. During the course of this project, employees learn how to conduct MIP projects successfully so the process can continue long after HEMPAC has departed, an approach that strengthens the company by allowing MIP to gain strong roots in the company's culture.

The MIP has been successfully implemented at several industrial plants located in central Minnesota and as a result, each of these plants is more productive and better equipped to support the nation should a critical need arise.

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For more information, circle Reader Response Number 5

# Ultra-Thin Nickel-Base Castings Improve Aircraft Engine Performance

Scientists and engineers at United Technologies Corporation, under contract with the Air Force Research Laboratory Materials and Manufacturing Directorate, have successfully developed a program for using advanced materials processing technology in the manufacture of propulsion and structural components.

These researchers are trying to develop cost-effective manufacturing processes capable of producing ultra-thin (20-30 mils) cast components that reduce engine weight, improve thrust-to-weight ratio, increase durability and improve range. These processes would also allow modifications to existing Air Force and Navy weapon systems where lightweight components are required and would provide the capability of manufacturing 100 percent retrofitable components.

Current state-of-the-art casting techniques are limited to 0.060-0.070 inch minimum thickness, so many cast aircraft turbine engine components are manufactured thicker than required by structural design and analysis. Continued improvements in gas turbine technology could lead to the development of lower-weight structural components with higher metal temperature capability. The feasibility of casting small-scale ultra-thin structures in the range of 0.020-0.030 inch thick has been demonstrated; however, the need still exists to exploit this technology for the cost-effective fabrication of reproducible and reliable large geometrically complex components.

Several processes have been used to demonstrate the capability to cast thin-wall nickel-base alloys but the optimum process has not been identified. The work to date has been limited to small-medium sub-element size pieces. Under this contract, research scientists and engineers developed a program aimed at applying advanced materials processing technology to the manufacture of propulsion and structural components. The program began with the casting process development and selection, followed by process demonstration, then hardware fabrication and qualification.

The components selected to demonstrate this process technology comprise the current baseline F119 turbine exhaust case, a multi-piece fabricated component consisting of 480 separate parts and nine manufacturing operations. A cast one-piece design will reduce the case to 112 separate parts and three manufacturing operations.

The program will be conducted in three phases with several subtasks per phase. During Phase I, a casting supplier and material was selected and a sub-element configuration was designed for casting process development trials. Rapid prototyping is being employed for the sub-element tooling and solidification modeling, and intelligent process control is being used throughout the technical effort. Sub-elements and mechanical property specimens have been evaluated to assess the casting process selected. In Phase II, a larger size sub-component based on the Phase I results was designed. The selected casting process is being optimized and employed to cast subcomponents for laboratory and engine testing on the Component and Engine Structural Assessment Research (CAESAR) engine. Following engine tests on the CAESAR, the subcomponents are being evaluated and a cost analysis is being provided for producing a full-scale component. Finally, a preliminary assessment of applicable repair methods for the cast subcomponent will be identified based on engine test experience and selected repair methods.

Ultra-thin cast nickel-base structural castings is a critical technology that will help reduce engine cost and weight, improve thrust-to-weight ratio, increase durability and improve range. This technology is capable of manufacturing 100 percent retrofitable components and is also applicable to castings on commercial engines. This development will result in a $40,000 per engine cost avoidance, which translates into a $24 million dollar cost avoidance over a 600-engine production buy.

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For more information, circle Reader Response Number 6

# Composite Radome Manufacturing Reduces Costs, Improves Durability

Scientists and engineers at the Raytheon Systems Company, under contract with the Air Force Research Laboratory's Materials and Manufacturing Directorate (ML), have successfully developed and tested a manufacturing process for fiber reinforced thermoplastic composite radomes which enables high volume production, reduces manufacturing labor costs and improves durability.

Tests indicate radomes built with the new thermoplastic material, Polyetherketoneketone (PEKK), require half as many labor hours as aircraft radomes currently in use and have a significantly longer life expectancy. These tests also indicate PEKK reduces water absorption and enhances foreign object impact resistance; both common problems with thermoset radomes.

Current technology for radomes and antennas uses composite materials consisting of hand-laid thermoset resin systems reinforced with glass, quartz or aramid fibers. The use of these materials, has resulted in chronic fabrication, long-term durability and environmental problems that increase costs and decrease reliability and maintainability. These problems have manifested themselves in four key areas: unacceptable moisture absorption decreasing performance, inadequate toughness and impact resistance, severe rain erosion (unless protected by a coating), and steep fabrication and repair costs.

Physical damage to aircraft radomes typically results from accidental impacts during ground maintenance, Foreign Object Damage (FOD) and hail and bird strikes while the aircraft is in flight. Such damage ranges from slight surface cracks to severe failure. Rain erosion causes deterioration of the radome over time and leads to degraded electronics and reduced structural strength. The long-term absorption of moisture causes undesirable changes in signal transmission, reflection and delay characteristics. Honeycomb sandwich structures in radomes are particularly vulnerable to these types of damage, primarily because of inherent brittleness and lack of toughness. High fabrication and repair costs associated with current radomes are due to long cure cycle times, resulting from the need to chemically cross-link the thermoset composites at the time of manufacture and are also incurred because fabrication methods usually entail elaborate manufacturing processes. Unlike thermoplastic composite materials, thermoset prepreg materials have a limited shelf life, must be stored at low temperatures and require frequent inspection.

Under this contract, scientists and engineers successfully developed and tested a new fiber reinforced composite material and forming process that reduces radome manufacturing labor costs by 50 percent and increases durability. Initial tests indicate PEKK reduces water absorption while increasing foreign object impact resistance; two crucial problems associated with the thermoset radomes currently used.

The program objectives were successfully achieved through the development of new technologies for radome construction, including the investigation of material characterizations, multiple radome applications, optimized rapid manufacturing techniques and the definition of specific process methods. These activities culminated in the production of an improved radome design for immediate use on the Air Force's RC-135 fleet of aircraft.

The manufacturing process and equipment developed in this program will make thermoplastic radome processing a high volume, low cost process. Other benefits include grouping of radomes into families, improved radome system supportability and better electronic system performance. Additional savings could be realized through repetitive use of a one-time tooling set-up.

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For more information, circle Reader Response Number 7

# Semiconductor Wafer Inspection Device Improves Fabrication and Reliability

An innovative research effort sponsored by the Air Force Research Laboratory Materials and Manufacturing Directorate has led to the successful development of a revolutionary technology that can detect sub-micron contaminant particles on unpatterned semiconductor wafers.

Developed by Sentec Corporation under the Small Business Innovation Research (SBIR) program, this technology can be used in a pre-fabrication environment to qualify wafers or monitor the fabrication process. The inspection device yields higher reliability, fewer defective production chips, less waste and lower costs, and helps strengthen the U.S. defense industrial base.

As semiconductor makers continue to reduce the size of chip features, ever smaller contaminant particles assume the characteristics of "killer" defects. According to the Sematech National Technology Roadmap for Semiconductors (November 1997), the line width of state-of-the-art semiconductor chips is expected to be 180 nanometers (nm) in 1999 and will continue to decrease in size until line widths reach 100 nm in 2006. At line widths of this size, a "killer" defect particle would be only about 33 nm in diameter.

Current scatterometer wafer inspection devices rely on the detection of the intensity of energy backscattered by contaminant particles which makes the detection of particles smaller than 80 nm difficult, time-consuming and expensive. The technology developed by Sentec presents a solution to that problem. The key to this new approach is that the device does not attempt to detect the intensity of energy backscattered from the contaminant particles, but instead detects the amplitude of the electo-magnetic field of the backscattered energy. This approach vastly improves detection sensitivity and allows the Sentec device to meet the future needs of the semiconductor industry by detecting much smaller contaminant particles at a throughput rate which is high enough to support in-line monitoring of semiconductor wafer processing. The device can also provide spectral information, which can be used to identify the contaminants on the wafer.

The technology developed for the unpatterned wafer inspection will allow semiconductor equipment manufacturers to advance into market areas which require increasingly smaller chip line widths. This tool will yield a higher reliability factor for the inspection of unpatterned wafers, fewer defective production chips, less waste and lower costs. The new technology offers promising expanded applications potential and successful transfer of this technology could lead to higher quality and lower costs in the commercial sector.

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For more information, circle Reader Response Number 8

# Roadmap Review/SBIR Industry Days Provide Insight On Planned Research Activities

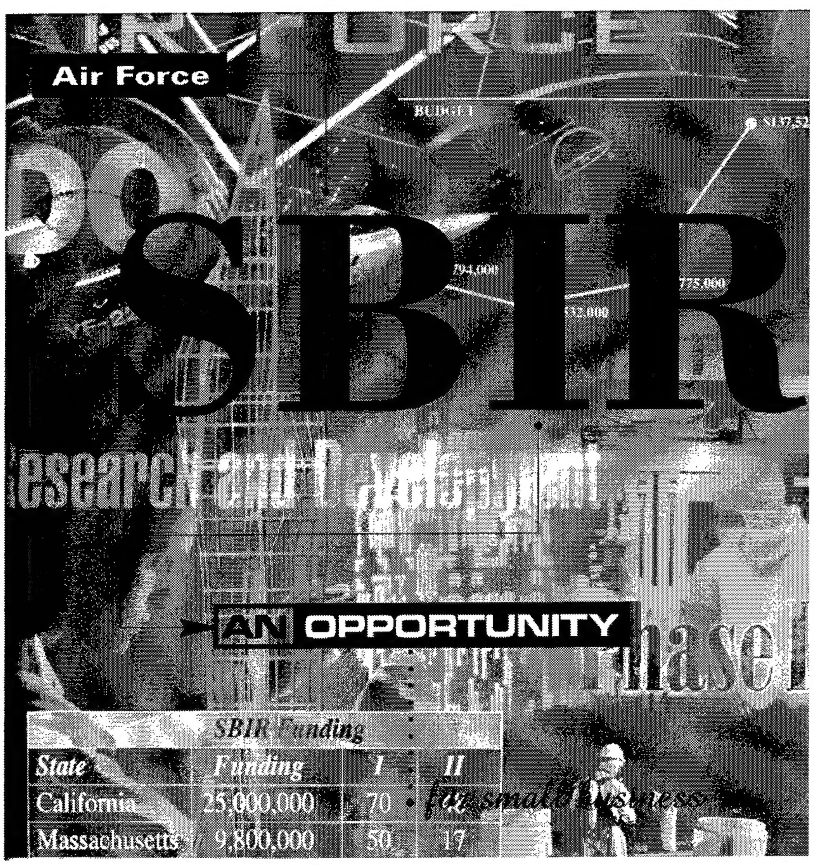
Leaders from industry, government and academia are getting together at the Dayton Convention Center July 20-22, to participate in the Air Force Research Laboratory Materials and Manufacturing Directorate (ML) 1999 Roadmap Review and Small Business Innovation Research (SBIR) Industry Days.

The Roadmap Review provides insight into planned Air Force materials and manufacturing research and development activities. It also provides an opportunity for participants to offer suggestions and ideas on future directorate research and development efforts. The review will feature breakout workshops offering opportun-ities to learn more about specific technology areas being pursued by ML researchers.

The SBIR Industry Days will allow researchers to present topics for aerospace materials research and development that require innovative solutions. Small businesses will compete for research funds to help solve these problems, and the facts and strategies learned at this meeting will help them prepare stronger, more competitive proposals.

The combined event will be hosted by the ML Director, Dr. Charles E. Browning, who will provide a complete overview of the Directorate and will discuss the Directorate's mission to help industry maintain an affordable defense materials and manufacturing capability.

For more information on the combined Roadmap Review/SBIR Industry Days, contact the Universal Technology Corporation at (937) 426-2808.



# Preparations Taking Place For Defense Manufacturing Conference

The 1999 Defense Manufacturing Conference (DMC '99) will be held Nov. 29 through Dec. 2, in Miami, Fla., at the Fountainbleau Hilton Hotel.

The conference is hosted by the Joint Defense Manufacturing (ManTech) Technology Panel. This panel identifies and integrates requirements, conducts joint program planning, develops joint strategies and oversees execution of the manufacturing technology programs conducted by the Army, Navy, Air Force, Defense Logistics Agency, and Defense Advanced Research Projects Agency.

DMC '99 will be a forum for presenting and discussing initiatives aimed at addressing critical defense manufacturing and sustainment needs. The agenda will be structured to provide participants with an overview of defense manufacturing technology and sustainment programs as well as detailed technical discussions relating to the various initiatives and the technology thrusts currently being pursued. Attendees will be presented not only with the status of both government and industry programs, but also with a vision for the future of defense manufacturing and sustainment. Hosted by the Navy, this year's conference will pave the way towards future successes in the affordable production and sustainment of both military and commercial products.

Last year's conference, DMC '99, held in New Orleans, La., was attended by over 940 industry and government representatives. The exhibit hall contained 87 exhibits sponsored by industrial corporations, centers of manufacturing excellence, industry associations, and government agencies and activities.

For more information, contact the DMC '99 Exhibit Manager at (937) 426-2808 (Fax: 426-8755).

# *End of Contract Forecast*

| DATE | PROJECT TITLE<br>CONTRACT NO. | PRIME CONTRACTOR | POINT OF CONTACT |
|---|---|---|---|
| July 1999 | Reproducible F-119 Turbine Exhaust Case (TEC) Castings<br>F33615-98-C-5160 | United Technologies Corporation<br>West Palm Beach, FL | Rafael Reed<br>(937) 255-2413 |
| July 1999 | Net Shape Casting Production Machine<br>F33615-97-C-5123 | Metal Matrix Cast Components Incorporated<br>Waltham, MA | David Judson<br>(937) 255-7371 |
| July 1999 | Integrated Product & Process Development (IPPD) Tools<br>F33615-96-C-5605 | Dayton Aerospace Associates Incorporated<br>Beavercreek, OH | George Orzel<br>(937) 255-4623 |
| July 1999 | Labor Infrastructure for Agile High Performance (AHP) Transformations<br>F33615-95-C-5512 | Work & Technology Institute<br>Washington, DC | Paul Bentley<br>(937) 255-7371 |
| August 1999 | Contributive Research & Development<br>F33615-94-C-5804 | Systran Corporation<br>Dayton, OH | Philip Mykytiuk<br>(937) 255-3953 |
| August 1999 | Fire Extinguishment by Electro-Magnetic Fields<br>F33615-97-C-5646 | Schneider Laboratories Limited<br>Alachua, FL | Juan Vitali<br>(805) 283-3734 |
| August 1999 | Enhanced Sensor Modules - III<br>F33615-96-C-5470 | Raytheon Company<br>McKinney, TX | James Theodore<br>(937) 255-4588 |
| August 1999 | A Study of New Permanent Magnet Materials for High Temperature Applications<br>F33615-97-C-5017 | Electron Energy Corporation<br>Landisville, PA | Gerald Simon<br>(937) 255-4588 |
| August 1999 | Process Modeling of Laser Shock Peening<br>F33615-97-C-5290 | LSP Technologies Incorporated<br>Dublin, OH | Joseph Burns<br>(937) 255-1360 |
| August 1999 | Low Cost C/Sic Ceramic Composites by Melt Infiltration<br>F33615-97-C-5286 | E I DuPont De Nemours & Company Inc<br>Newark, DE | Kenneth Self<br>(937) 255-9820 |
| August 1999 | Conductive Polymer-Silver Nanocomposite Wires for USAF Satellites & Aircraft<br>F33615-98-C-5049 | Triton Systems Incorporated<br>Chelmsford, MA | Loon-Seng Tan<br>(937) 255-9141 |
| August 1999 | Repair of Ceramic Matrix Composites - DC<br>F33615-95-C-5243 | Dow Corning Corporation<br>Midland, MI | Paul Jero<br>(937) 255-9818 |
| August 1999 | Development of Resin Transfer Molding Technology<br>F33615-96-C-5057 | North Carolina A&T State University<br>Greensboro, NC | James McCoy<br>(937) 255-9063 |
| August 1999 | Thermochemical & Thermophysical Properties of Fluids & Lubricants<br>F33615-95-C-5027 | Phoenix Chemical Laboratory<br>Chicago, IL | Carl Snyder Jr<br>(937) 255-9036 |
| August 1999 | Optimal Design of Bulk Forming Processes<br>Numerous | Rensselaer Polytechnic Institute<br>Troy, NY | David Judson<br>(937) 255-7371 |
| August 1999 | Supply Chain Management for Electronics Manufacturing with Product Recovery and Remanufacturing<br>Numerous | Purdue University<br>West Lafayette, IN | David Judson<br>(937) 255-7371 |

| DATE | PROJECT TITLE<br>CONTRACT NO. | PRIME CONTRACTOR | POINT OF CONTACT |
|---|---|---|---|
| August 1999 | A Distributed Decision Framework Integrating Manufacturing Planning and Supply Chain Management<br>Numerous | Lehigh University<br>Bethlehem, PA | David Judson<br>(937) 255-7371 |
| August 1999 | Oregon International Internship Program<br>F33615-95-2-5552 | Oregon State University<br>Corvallis, OR | Patrick Price<br>(937) 255-4623 |
| August 1999 | Design and Manufacture of Low Cost Composites (DMLCC), Bonded Wing<br>F33615-91-C-5729 | Textron Corporation, Bell Helicopter<br>Fort Worth, TX | Vincent Johnson<br>(937) 255-7277 |
| September 1999 | Lean Aerospace Initiative (LAI)<br>F33615-93-2-4316 | Massachusetts Institute of Technology<br>Cambridge, MA | John Klempay<br>(937) 255-3701 |
| September 1999 | Flat Panel Displays<br>Multiple | Boeing Company<br>St Louis, MO | John Blevins<br>(937) 255-3701 |
| September 1999 | Life Prediction of Aging Aircrft Wiring<br>F33615-96-C-5633 | Materials Technology Corporation<br>Monroe, CT | George Slenski<br>(937) 256-9147 |
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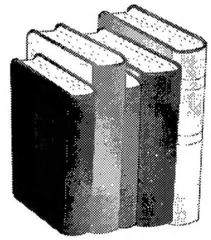

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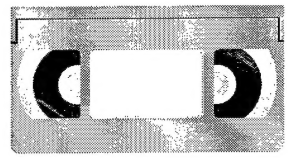

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# PROGRAM STATUS REPORT

**Summer 1999**

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